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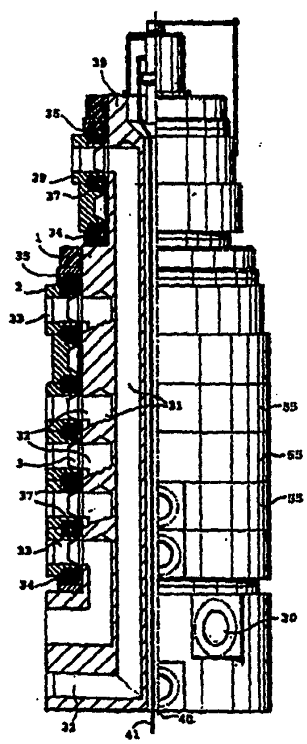
(54) Title: FLUID SWIVEL CONNECTOR

(57) Abstract

A connector arranged for high pressure fluid carrying conduits comprises a central core (1) having at least one fluid passage such as an integral bore (31), formed therein and an outer member surrounding the central core and being moveable relative thereto. The outer member comprising at least one segment (55) having a fluid flow conduit and sealing means for the connector junction comprising an intermediate member, at least one static seal for non-moveable surfaces and at least one dynamic seal for relatively moveable surface. A plurality of segments may be stacked on top of each other and held together by the application of a compression force on shoulders of the segments. A relative rotational capability is preserved for the parts of the connector yet a more reliable and versatile connector is achieved in which the modular construction allows a variety of sizes to be offered more easily and cheaply and engineering tolerances can be more easily met than with a single piece construction.



Fluid swivel connector

FIELD OF THE INVENTION

The present invention relates to a high pressure fluid connector.

Such connectors are needed for example in transferring oil or gas from offshore drilling installations onto transport vessels.

The connectors may be a part of floating buoys carrying the riser from the undersea extraction point to which an oil tanker links up to load the oil or gas. Alternatively the connector may be fixed on the deck of the transport vessel. It is also possible say for one part of the connector to be on the vessel and the other part to be in the floating buoy.

Relative movement between the parts of the connector is important for such applications to allow for relative movement of the vessel and the riser in strong winds, high waves or influential currents.

A relative rotational capability is particularly advantageous and the connector may form a swivel joint between conduits. Of course such a swivel joint presents difficulties with regard to ensuring correct and accurate alignment of the ends of corresponding fluid conduits and in sealing the conduit join against leakage.

BACKGROUND OF THE INVENTION

One known flow connector is described in US 4 828 292 and comprises two concentric hollow cylindrical parts, relatively rotatable with respect to each other and having cooperating aligned annular grooves to form circumferential passages within the connector delimited by the inner walls of the two parts. Inlet and outlet pipes are welded to the

inner and outer cylindrical parts as appropriate and connect with the annular circumferential passages. In this way, even with rotational movement of the two parts, the inlet and outlet pipes communicate at all times via the annular passages. Annular ring seals are incorporated on each side of the passages and may be pressurised by a barrier fluid.

However, this known design is difficult and expensive to manufacture with sufficiently accurate tolerances, the welded joints are often prone to failure particularly under the high pressures and in the dirty environment of oil and gas production facilities, and it is a permanent structure once manufactured i.e. it cannot easily be connected and disconnected even for routine maintenance and repair. In addition, the seals are subject to a high degree of wear and experience attendant high failure rates.

DISCLOSURE OF THE INVENTION

Accordingly the present invention provides an arrangement for connecting high pressure fluid-carrying conduits, the arrangement comprising a central core having a plurality of fluid passages formed therein and an outer member surrounding the central core and being moveable relative thereto, the outer member comprising a plurality of segments, each segment having a fluid flow conduit communicating with a respective fluid passage in the central core, there being sealing means for sealing against leakage of production fluid at the junction between the conduit in the outer member and the passage in the central core, the sealing means comprising an intermediate member connected to the core by at least one static seal and sealing against relatively moveable surfaces by at least one dynamic seal.

Preferably the sealing means is constructed according

to the invention described in applicant's co-pending simultaneously filed U.K. application number 95 22 326.9 entitled "Sealing Arrangements".

A plurality of segments may be stacked on the central core and connected in a manner which allows some relative movement between them. They may be retained in relative juxtaposition by applying a compression force to the stack, e.g. by a compression nut. The force is taken by shoulder portions of the segments positioned adjacent the central core.

An arrangement according to the present invention is more reliable and versatile than known connector arrangements and its modular construction allows for a variety of sizes of connector to be built to order relatively easily. The modular structure also makes it easier to meet the strict engineering tolerances required in this field, compared to the single piece construction.

The use of axial bores as fluid conduits in the central core is also an advantage and particularly the arrangement described in applicant's co-pending and co-filed U.K. application number 95 22 325.1 entitled "Fluid Flow Connector".

A monitoring systems for the sealing means of the connector may be incorporated, preferably as described in applicant's co-pending co-filed U.K. application number 95 22 340.0 entitled "Monitoring System for High Pressure Fluid Flow Connector".

For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 shows a fluid connector arrangement according to one embodiment of the present invention, in part cross-section and in part elevational view.

Figure 2 shows a fluid connector arrangement according to a second embodiment of the present invention, in part cross-section and in part elevational view.

Figure 3 is a cross-sectional view of a single segment of the fluid connector of Figure 1.

Figure 4 is an enlarged view of a part of the segment of Figure 3 showing the sealing means therefor in more detail.

Figure 5 is a cross-sectional view of a third embodiment of a fluid connector according to the invention.

Figure 6 is an enlarged view of a single segment of the fluid connector of Figure 5.

DETAILED DESCRIPTION OF DRAWINGS

Figure 1 illustrates a high pressure fluid connector. In the left half of the Figure a cross-sectional view is shown. In the cross-sectional view, oppositely directed cross -hatching is used to indicate parts of the connector which are relatively rotational with respect to each other. Thus a male member 1 is denoted by a left to right rising cross-hatching and a female member 2 is denoted by left to

right falling cross-hatching. The male member 1 is generally held stationary, for example on a storage or transport vessel to which the oil or gas is being pumped through the connector.

The male core member 1 has several axial bores 31 connecting radial passageways 32 in core element 1 each of which connect with fluid conduits 33 in the female member 2. The junction of these fluid conduits with the radial passageways 32 in male member 1 is formed as an annular groove 3. In this way the relative rotation of the two members 1 and 2 does not affect the fluid connection between the two.

This junction of the fluid conduits and the passageways is sealed by means of over-pressure double sealing arrangements above and below each junction, coaxial with the annual grooves. These sealing arrangements are indicated generally at 37 and are described in more detail with reference to Figure 4 and also in applicant's co-pending and simultaneously filed British application number 95 22 326.9 entitled "Sealing Arrangement".

This sealing arrangement comprises sealing rings in the form of double pairs of lip-seals each having U-shaped cross-sections and being activated by a high pressure barrier fluid applied to the open side of the U-shape. The barrier fluid is supplied at a higher pressure to the pressure of the fluid in the conduit and provides a lubrication for the seal to facilitate relative rotation of the members 1 and 2 with a minimum of wear on and damage to the seal.

Such a sealing arrangement is provided in each of the segments 55 of the outer member 2, above and below each

annular groove 3.

At the top and bottom of the stack of the segments 55 is provided an environment seal 34, 35 which seals the set of segments and their fluid carrying conduits against the atmosphere. The environment seals each comprises a pair of spaced U-shaped seals activated by pressure differentials in a similar manner to the dynamic lip seals above and below each annular groove.

In the embodiment shown in Figure 1 the core element 1 comprises an additional extension portion 38 extending longitudinally beyond female member 2, and having a smaller diameter. This connects with a second female member 39 in the same way as has been described in relation to the first female member 2. That is to say that sealing arrangements 37 as well as environment seal 34, 35 are provided. Such a narrower diameter core extension is useful for particularly high pressure fluid flow.

A central axial bore 40 in core 1 carries electrical wires 41 (Figure 1) and/or other support lines and power supplies for the connector and the pipeline.

Figure 2 shows an alternative arrangement to that of Figure 1 where the arrangement is identical except that the male member 1 takes the form of an outer core member 43 and an inner core member 42 which fits coaxially into the outer core element 43. All other components are denoted by like reference numbers.

This embodiment has advantages in the manufacture of the arrangement since the concentric cores can be made independently and assembled after machining, leading to reduced manufacturing costs, more accurate tolerances and allowing larger diameter fluid connectors to be constructed

than would otherwise be possible. In addition, each core element may be made of a different material which may be chosen according to the fluid to be transported in the particular section. For example a particularly corrosive production fluid may require to be transported in conduits of a strong corrosion-resistant material which may be prohibitively expensive if used for the whole core. With this embodiment however, only one part of the core need use such expensive material.

The inner core member 42 has axial bores 31a of a smaller diameter to those in the outer core element. These bores 31a communicate fluidly in pairs with radial passageways 32a. Each set of axial bores is arranged in a ring.

This arrangement improves the capacity of the connector to carry many different fluids simultaneously and independently since it provides the possibility to provide a larger number of bores in the central core. Also bores of different diameters for different fluid flows can be made more easily. Smaller diameter bores are generally used for higher pressure fluid conduits.

Figure 3 illustrates a segment 55 of the connector of Figure 1 showing joint between fluid conduits. The conduits are joined so as to allow a relative rotation of parts at the joint and for ease of reference those parts which move relative to each other are denoted by oppositely directed cross-hatching. In the specific embodiment shown in Figure 3, a core swivel member 1, denoted by left to right rising cross-hatching is a stationary male member whereas the connecting member 2, denoted by left to right falling cross-hatching is a female member which is rotatable about member

1. Axial bores (shown in Figure 1) in male member 1 are connected via radial passages (shown in Figure 1) to annular grooves 3 forming a junction of the male and female members 1 and 2. These annular grooves 3 connect with passageways (shown in Figure 1) in the female member 2 so that fluid such as oil or gas can be transferred, for example from an oil pipeline riser to a transport vessel such as an oil tanker.

In the embodiment shown in Figure 3, surfaces which are moveable relative to each other are indicated by the junction of opposite cross-hatching. Hence it can be seen that the surfaces 4 and 6 of male member 1 move relative to the surfaces 5 and 7 respectively of female member 2. In order to allow for relative rotation of the members 1 and 2, there must be a small clearance between these relatively moveable surfaces and this provides a potential fluid leakage path for the production fluid from the conduits and in particular from the annular groove 3.

Thus, a sealing arrangement is incorporated to seal this small clearance gap. In particular a pair of primary lip seals 8, 9 with U-shaped cross sections are arranged in respective channels 10, 11 above and below the annular groove 3. These primary seals are pressurised by a barrier fluid supplied via a supply channel 44 in female member 2. The supply channel branches to provide barrier fluid into each of the grooves 10, 11 to pressurise the primary seals 8, 9. The barrier fluid through channel 44 is supplied at a pressure slightly above the pressure of the production fluid in the annular channel 3 and thus the arms of each of the U-shaped sealing rings 8, 9 are forced against respective relatively moveable surfaces and retain the

production fluid within channel 3.

Typically the pressure of the production fluid, e.g. gas or oil, may be of the order of 500 bar and the barrier fluid would preferably be under a pressure of around 520 bar. These values are given by way of example only and are in no way intended to be limiting on the pressure which could be used in a sealing arrangement according to the present invention which would be chosen by a person skilled in the art according to the particular circumstances and requirements of the apparatus.

To improve the efficiency of the seal, at least one of each adjoining surface (4/5 or 6/7) is coated with a hard smooth coating such as tungsten carbide. In general it is easier to provide such a coating onto a predominantly flat surface and thus in the embodiment illustrated this coating would be on surfaces 5 and 7. The material of the sealing rings 8, 9 is preferably a plastics material thus providing a relative soft member to seal against the hard smooth surface of tungsten carbide to provide an efficient seal.

In practice, because the barrier fluid in channel 44, and in grooves 10, 11, is at a higher pressure to the production fluid against which sealing is being effected, so that any net flow would be from the barrier fluid channel into the production fluid conduit. Thus in practice the barrier fluid effectively lubricates the sealing rings 8, 9 and facilitates the relative movement between the sliding surfaces. An extremely small net fluid loss of the barrier fluid will be experienced but this is insignificant compared to the many millions of gallons of product which would usually flow through the conduits across the joint, and is of course preferable to leakage in the opposite direction

which would happen if the primary seal were not an over-pressure seal.

A secondary seal for the joint is provided in the form of secondary sealing rings 12 and 13 seated in channels 14 and 15 of surfaces 4 and 6 respectively.

These secondary channels 14 and 15 are spaced from the primary channels 10 and 11 and are also provided with a barrier fluid under pressure via supply channel 16 located within the female member 2. The barrier fluid for the secondary seals 12 and 13 forms part of a separate supply circuit to that for the primary seals 8 and 9 and thus channel 16 is not connected to channel 44. However the barrier fluid for the secondary sealing rings 12 and 13 is supplied at the same pressure as the barrier fluid for the primary sealing rings 8 and 9. Therefore the same barrier fluid pressure is applied to both sides of each of the secondary sealing rings 12 and 13 then the secondary sealing rings are not activated under normal usage conditions (ie when the primary sealing rings are intact).

In the embodiment shown a bearing is provided between relatively rotatable surfaces 6, 7 and 4, 5 respectively. This may be a sliding bearing as shown at 17 in Figure 1 or alteratively a roller bearing.

In the embodiment of Figure 3 many static seals are also shown. These are provided to lock various parts or elements together and may comprise U-shaped cross-sectional seals as denoted by 18 or O-ring seals 19 with back-up plates 20.

The back-up plate in the O-ring seals 19 prevents extrusion of the seal through the gap between the surfaces being sealed, which otherwise does tend to occur under high

pressure.

The U-shaped static seals 18 are provided in grooves in a sealing surface element 21 to hold it to the main body of female member 2. Bolts 22 are also arranged to hold these elements together. The head of the bolt sits in a recess 24 in a connecting member 25 which serves to fasten this segment of female member 2 to an adjacent similar segment. The connecting member 25 is further attached to the female member by static seals formed of O-rings 19 and back-up plates 20.

The primary and secondary sealing ring channels are formed in an intermediate member 26 which is fixed to the male member 1 by means of a key 27 and static seals 28.

A distance ring surrounds the male member 1. The arrangement of Figure 3 is repeated in a stack of modules as shown in Figures 1 and 2. Each module may carry fluids of different types or fluids in different directions. The distance ring 29 has shoulders which abut adjacent corners of the intermediate members 26 to take the compression forces holding the stacked segments or modules together.

Figure 4 is an enlarged view of the sealing arrangement for a single segment and like parts are denoted by like reference numbers.

In addition Figure 4 clearly shows environment seals 34 and 35 at the bottom and the top of the stack of modules of Figure 1. These comprise a pair of spaced U-shaped sealing rings which seal the relatively rotatable surfaces at the top and bottom of the apparatus respectively from the external environment, which will generally be at atmospheric pressure.

These environment seals also comprise a pair of lip-

seals having substantially U-shaped cross-sections and they are located in spaced grooves in one of the relatively rotatable surfaces. A barrier fluid under pressure is supplied to the open sides of each of these seals and typically the barrier fluid would be supplied at the same pressure as the barrier fluid for the primary and secondary joint seals. The environment seals operate in the same way as the dynamic seals but this time they are sealing against atmospheric pressure and therefore the outer seal 34 is effectively the operative primary seal. The barrier fluid pressure here will be substantially more than the environmental pressure (when this is atmospheric pressure) and this provides a very effective seal for this application. Nonetheless a secondary seal 35 is provided of substantially similar design and the secondary barrier fluid is supplied to this secondary seal. Because the same pressure is applied to the open side of seal 34 as to the open side of seal 35 then this secondary seal will again not be operable until or unless the primary seal fails.

When the primary seal does fail, there will be a leakage path for barrier fluid from the primary seal to escape to the atmosphere but the drop in pressure across the primary seal causes a pressure differential across the secondary seal 35 and activates the secondary seal.

Under normal circumstances this environment seal is an ultimate level of protection against product leakage from the production fluid conduits. Before the environment seal is needed, both the primary and secondary seals would need to fail in the segment or module at the top or bottom of the stack. Nonetheless, it is of course vitally important that a production fluid such as oil does not leak into the

environment.

Figure 5 shows a lower, large diameter male connector 56 with an upper small diameter connector 57 stacked on top, each having a hollow central portion 59.

Each of these male connectors (56,57) has longitudinal bores for fluid transport which connect with respective radial passageways, annular grooves and conduits in co-operating female members, as has been described with reference to the Figures 1 and 3 above. The bores and passageways of lower connector 56 are not shown in Figure 5. The bores 31 of the upper connector 57 connect to pipes 58 which are located in the hollow central part 59 of lower connector 56. Seals 60 are arranged at the junction of bores 31 and pipes 58 and these may be of any of a variety of known constructions.

The upper connector 57 also has a hollow central part 61. The upper and lower connectors 56,57 each have a solid core surrounding their hollow centres and through which the longitudinal bores are drilled for transport of fluid.

The upper and lower male connectors each have separate co-operating female connectors. In Figure 5 the lower female connector is not shown but the upper one is indicated at 62.

The junction of the fluid carrying conduits between the male and female parts is sealed in a similar way to the system described for the embodiments of Figures 1 and 3, and is also described in applicant's co-pending and simultaneously filed application number 95 22 326.9 entitled "Sealing Arrangement". However, in Figure 5 a different arrangement of the parts is used and this is illustrated in larger scale in Figure 6 which is a cross-section through a

part of one fluid conduit junction.

The arrangement of parts at this junction will now be described in detail with reference to Figures 5 and 6.

The annular grooves 3 in the embodiment of Figure 5 are formed between the female member 2 and key pieces 63 which are bolted to the core of male member 57 by bolts 64. This makes the male member 57 simpler to construct and the tolerances required for the fluid conduits are easier to achieve in these smaller individual parts.

Above and below each annular groove is a double sealing arrangement each comprising primary 8,9 and secondary 12,13 sealing rings in respective grooves. The sealing rings are lip seals with U-shaped cross-sections. They are arranged with the open arms facing away from the fluid path defined by annular groove 3. In this embodiment this is radially inwardly of the connector in contrast to the arrangement of the embodiments described above where the arms face radially outwardly (but still away from the fluid path).

These sealing rings seal the production fluid against leakage in the clearance between relatively moveable surface 4,5 below the groove 3 and 6 and 7 above. They are thus known as dynamic seals. They are activated by pressurised barrier fluid applied through channels 44 to the open side to create a pressure differential.

Roller bearings 65 are provided to assist the relative movement between surfaces 4 and 5 and between surfaces 6 and 7. Sliding or needle bearings 66 assist movement between facing vertical surfaces.

Static seals 28 comprising O-rings 19 and back-up plates 20 are also used in the connector as shown, but these

are used between surfaces which have a fixed relationship to each other. These static seals may alternatively comprise U-shaped lip seals pressurised by barrier fluid supplied through drilled communication channels.

Environment seals 34,35 are arranged above and below each section of connector.

CLAIMS:

1. An arrangement for connecting high pressure fluid-carrying conduits, the arrangement comprising a central core having a plurality of fluid passages formed therein and an outer member surrounding the central core and being moveable relative thereto, the outer member comprising a plurality of segments, each segment having a fluid flow conduit communicating with a respective fluid passage in the central core, there being sealing means for sealing against leakage of production fluid at the junction between the conduit in the outer member and the passage in the central core, the sealing means comprising an intermediate ring member connected to the core by at least one static seal and sealing against relatively moveable surfaces by at least one pressure activated dynamic seal, means for supplying a barrier fluid, at a pressure higher than the pressure of the production fluid, to the pressure activated dynamic seal, so that when the seals are activated the outer member is rotatable relative to the intermediate ring member and the intermediate ring member is fixed relative to the central core.

2. An arrangement according to claim 1, wherein the segments of the outer member are stacked and wherein each segment comprises means for connecting adjacent segments so as to allow limited relative motion therebetween, and the arrangement comprises

means for applying a compression force to the stacked segments,

each segment comprising a shoulder portion on which the compression force acts to retain the stacked segments in relative juxtaposition.

3. An arrangement according to claim 2, wherein the shoulder portions are positioned adjacent the central core.

4. An arrangement according to claims 2 or 3 wherein each segment is separated from an adjacent segment by the

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intermediate member which has grooves in which the dynamic sealing means is arranged, the position of each intermediate member relative to the central core being fixed.

5. An arrangement according to claim 4 wherein each intermediate member is fixed relative to the central core by means of a key located partly in a groove in the intermediate member and partly in a groove in the central core.

6. An arrangement as claimed in any preceding claim, wherein at least one of the static seals seals the intermediate member to the central core.

7. An arrangement for connecting high pressure fluid carrying conduits as claimed in claim 6, wherein the or each static seal comprises a U-shaped annular ring seal surrounding the central core.

8. An arrangement as claimed in claim 7, comprising two U-shaped annular ring seals surrounding the central core with the openings of the U facing toward each other.

9. An arrangement for connecting high pressure fluid carrying conduits as claimed in any preceding claim, comprising fluid pressurising means for the or each static seal.

10. An arrangement for connecting high pressure fluid carrying conduits as claimed in claim 7,8 or 9, wherein a resilient expansion member is arranged between the arms of

the or each of the U-shaped seals to tension the or each static seal.

11. An arrangement for connecting high pressure fluid carrying conduits as claimed in any one of claims 2 to 10 comprising a distancing ring positioned radially inwardly of each segment and abutting each respective intermediate member and the distancing rings having cooperating shoulders for transferring the compression force between the segments.

12. An arrangement for connecting high pressure fluid carrying conduits as claimed in any preceding claim wherein the dynamic sealing means comprises sealing rings having sealing surfaces and the arrangement comprising means for interconnecting each segment member with an adjacent segment member and intermediate member.

13. An arrangement for connecting high pressure fluid carrying conduits as claimed in claim 12, wherein the interconnecting means is a bolt.

14. An arrangement for connecting high pressure fluid carrying conduits as claimed in claim 12 or 13, wherein the interconnecting means allows relative motion between the interconnected parts.

15. An arrangement for connecting high pressure fluid carrying conduits according to any preceding claim wherein the dynamic seals comprise differential pressure seals.

16. An arrangement for connecting high pressure fluid carrying conduits according to any preceding claim wherein the static seals comprise O-rings seals.

17. An arrangement for connecting high pressure fluid carrying conduits according to claim 16 comprising backing plates on the lower pressure side of the O-ring seals.

18. An arrangement for connecting high pressure fluid carrying conduits as claimed in any preceding claim comprising bearings between relatively moveable surfaces.

19. An arrangement for connecting high pressure fluid carrying conduits as claimed in claim 18, wherein the bearings are roller bearings.

20. An arrangement for connecting high pressure fluid carrying conduits as claimed in claim 18, wherein the bearings are needle bearings.

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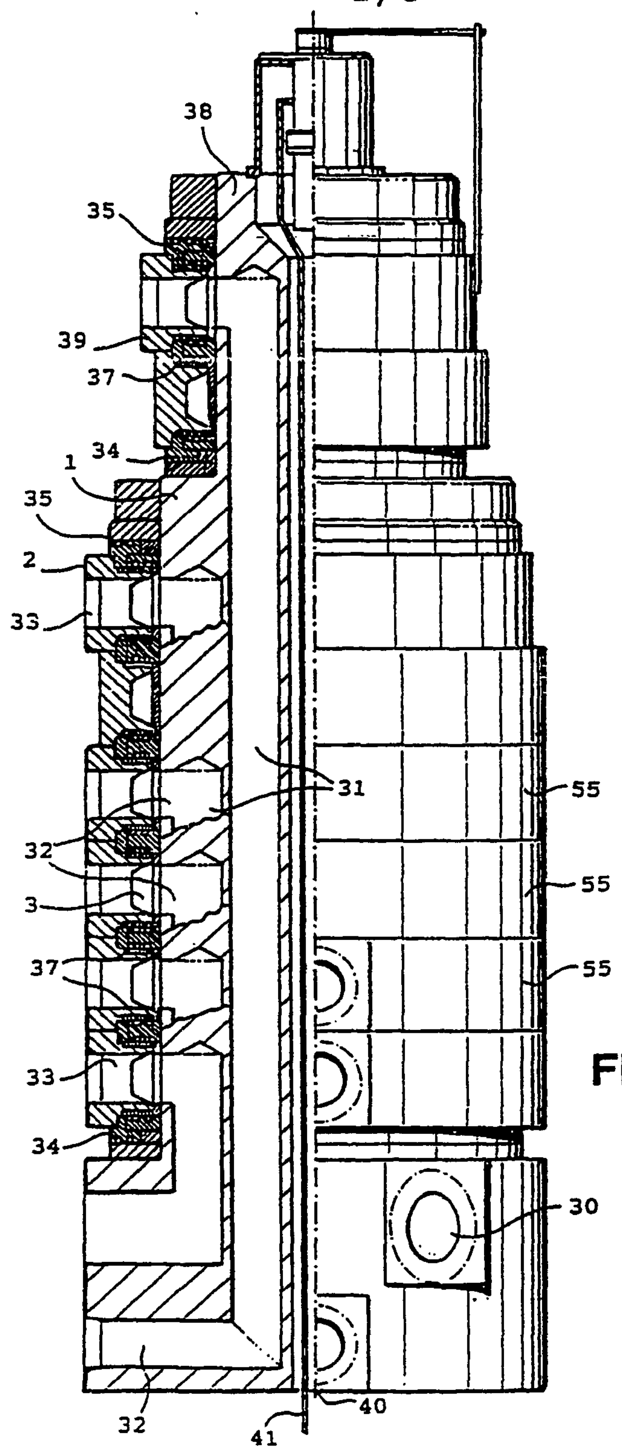

FIG. 1

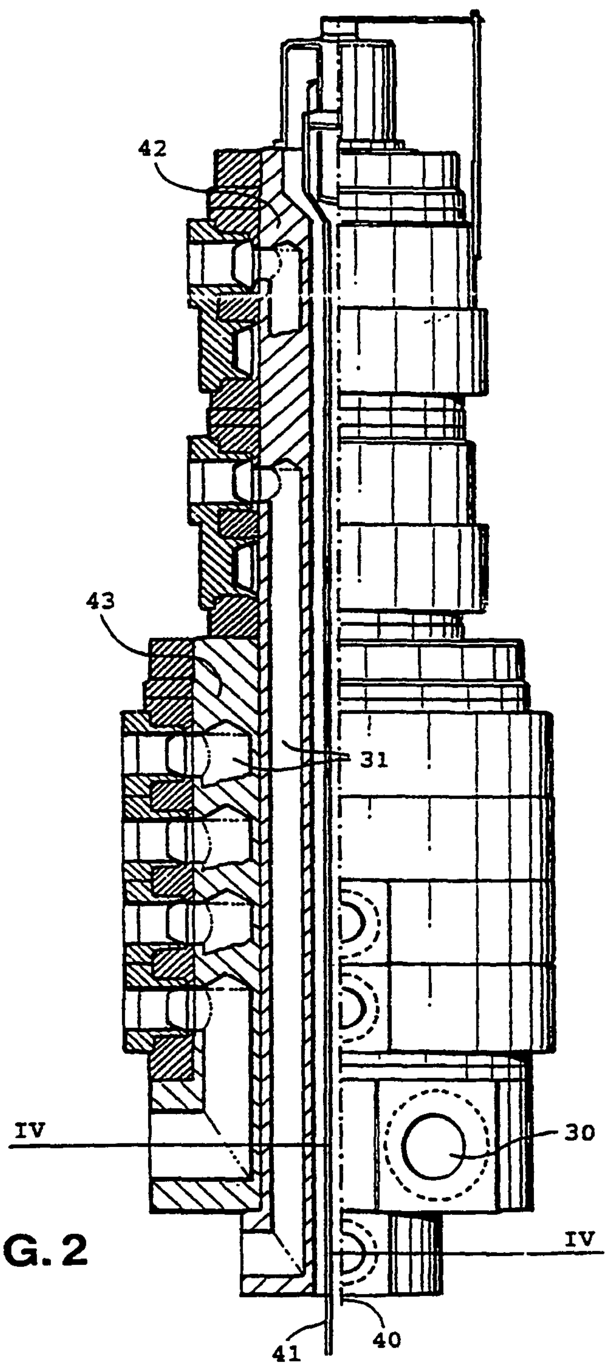

FIG. 2

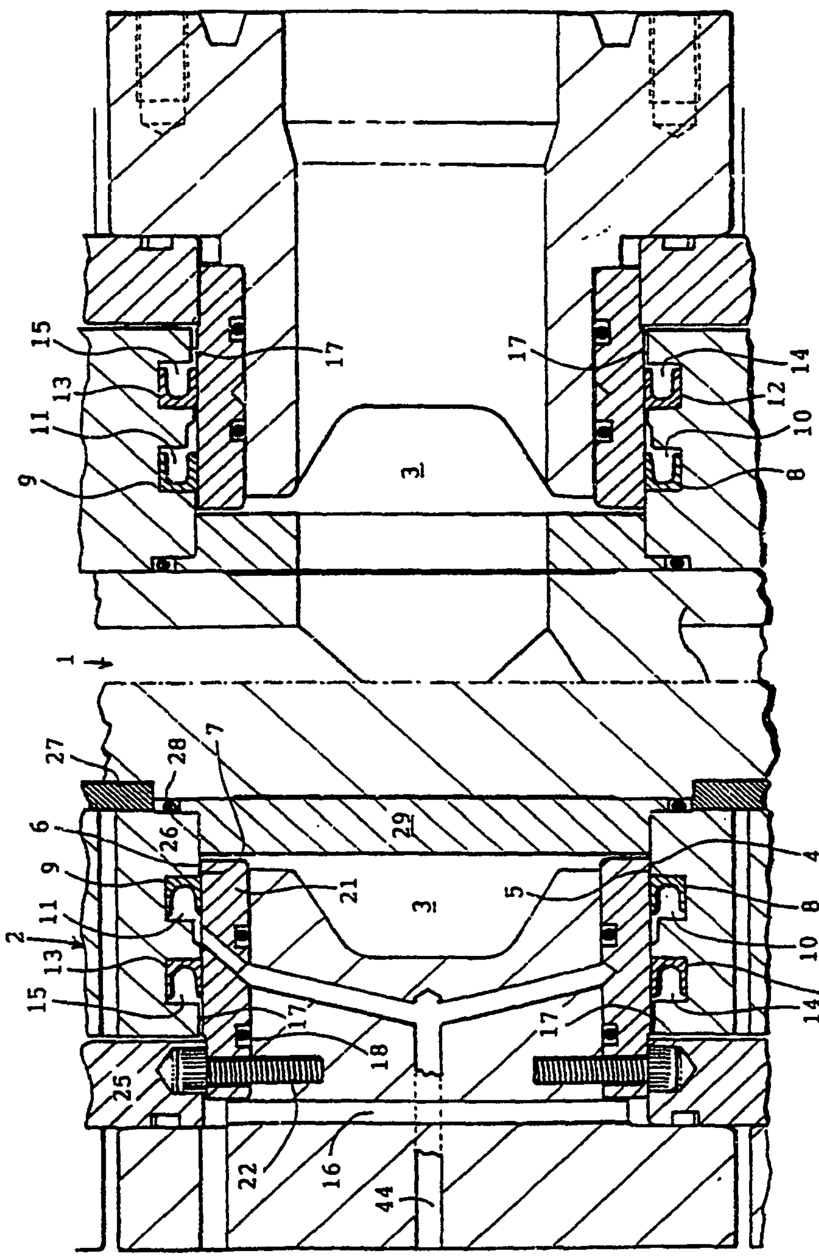
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FIG. 3

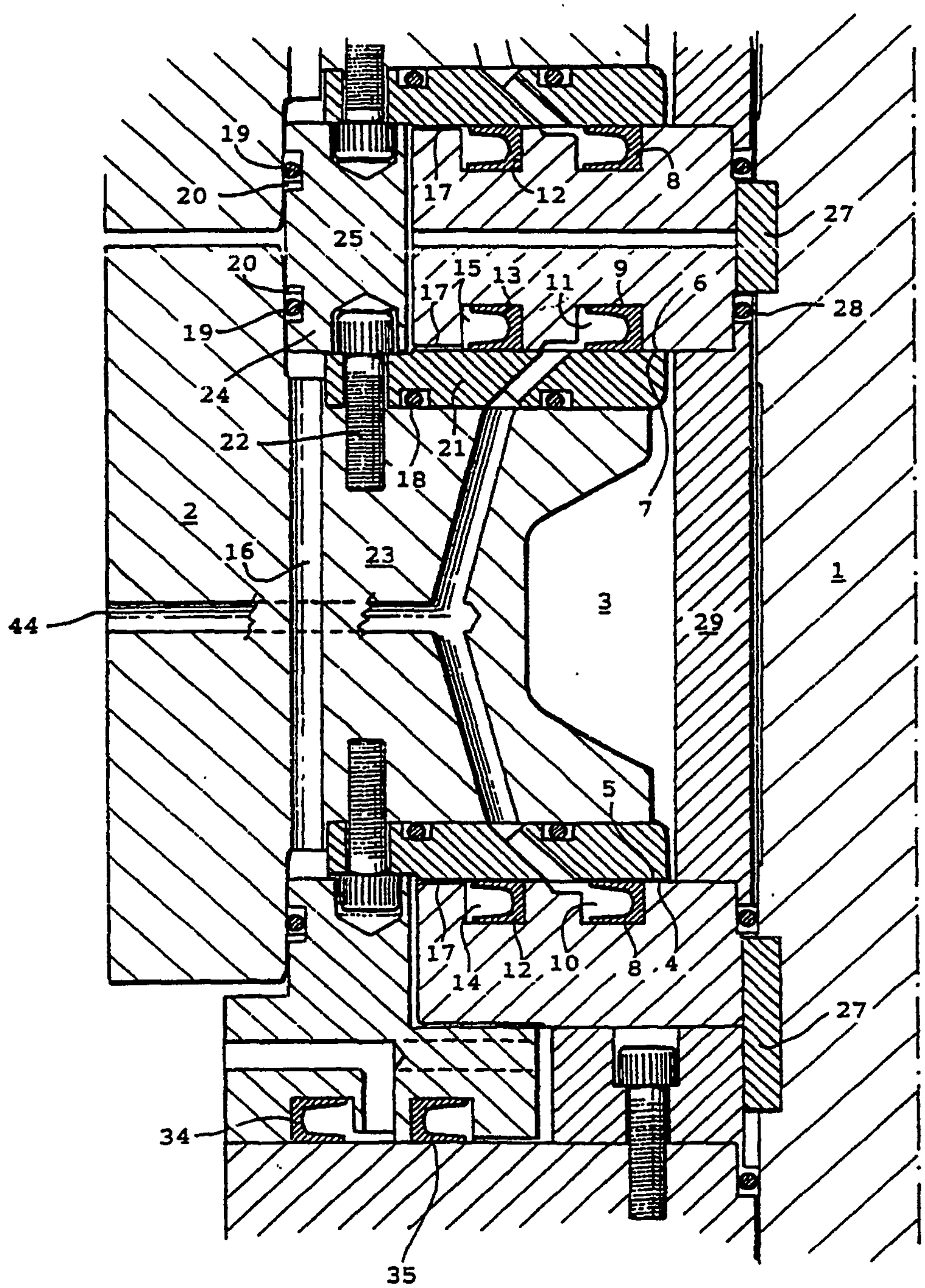
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FIG. 4

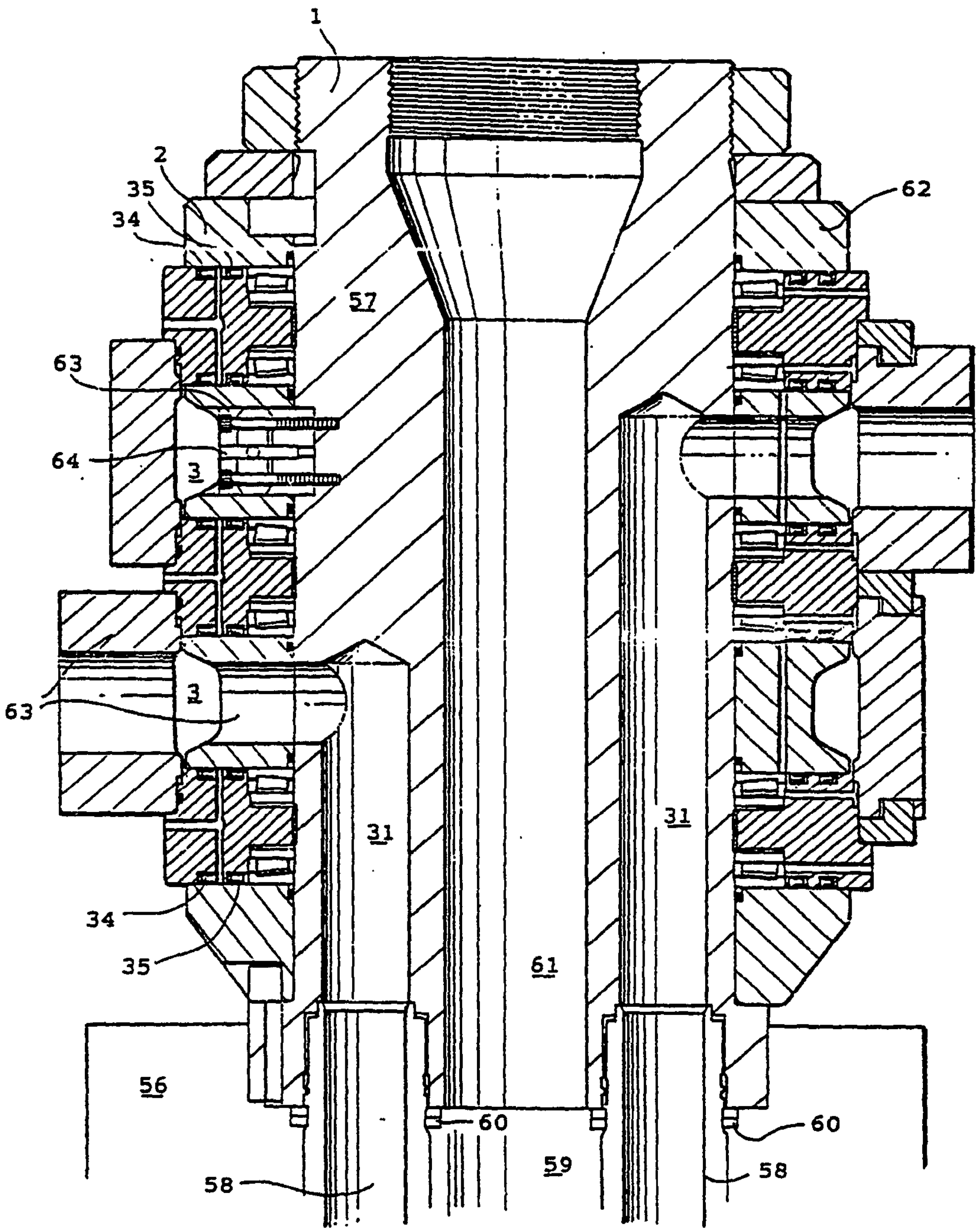

FIG. 5

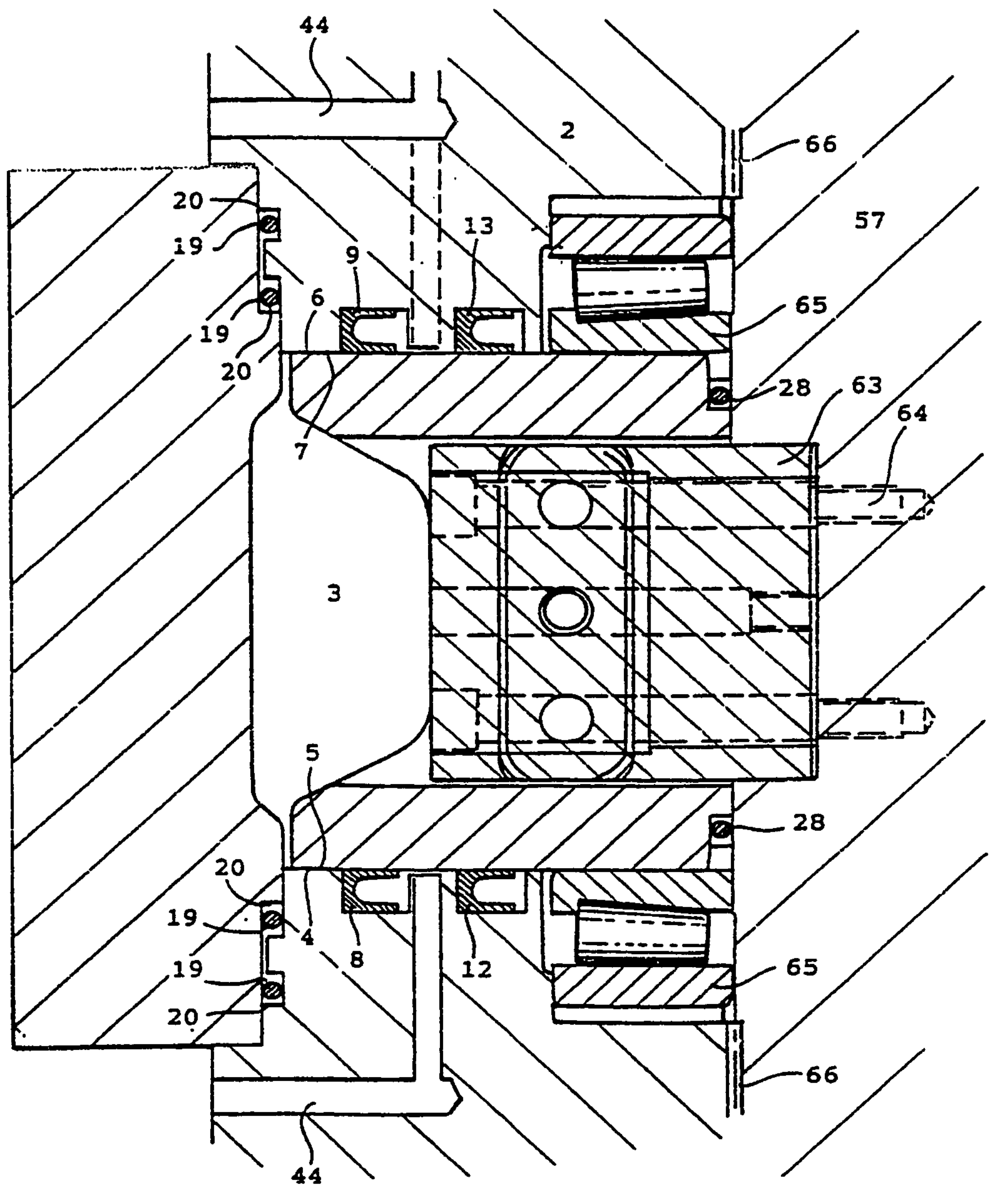
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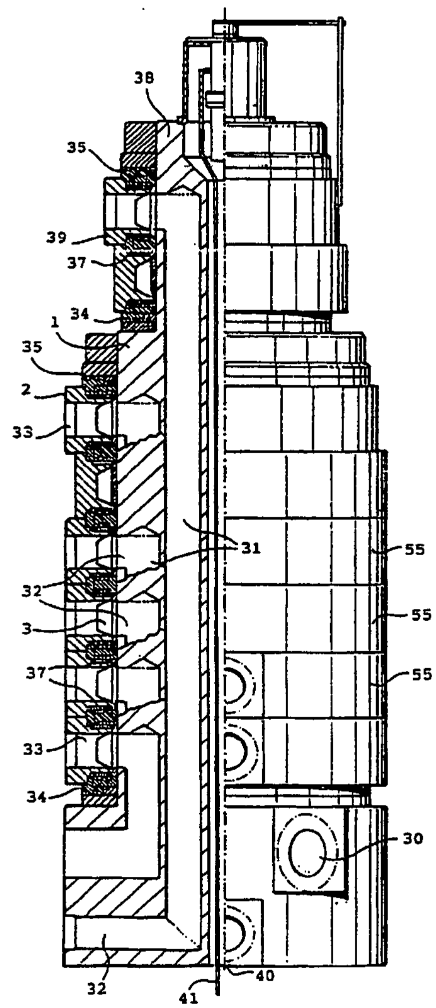
FIG. 6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